

# CURRICULUM VITAE

February, 2008

**MAWUADEM KOKU AMEDEKER**, MInstPhys.  
(Chartered Physicist)

Department of Science Education  
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## 1. Personal Information

**Marital Status:** Married with one child

**Date of Birth:** 1<sup>st</sup> March, 1954

**Place of Birth:** Mepe, Volta Region

**Nationality:** Ghanaian

## 2. Promotion

Senior Lecturer      3<sup>rd</sup> June, 1999

## 3. Educational Institutions and Qualifications

University	Subject	Title	Grade/Year
i. Edith Cowan University Perth, Western Australia	Science Educ.	Ph.D.	completed 2007
ii. The University of Manchester, U. K.	Theor. Physics	M. Sc.	Pass (1995)
iii. University of Cape coast, Ghana	Physics/Mathematics	B. Sc.(Ed)	2 <sup>nd</sup> Class (Lower) 1977

<b>4. Awards Received</b>	<b>Awarded By</b>	<b>Year</b>
i. International Postgraduate Research Scholarship for Ph. D. (Science Educ.)	Edith Cowan University (Perth- Australia)	April, 2005 - Dec. 2007
ii. Visiting Associate to Institute of Theoretical Physics Beijing, - China.	Third World Academy of Science (ICTP- Italy)	Jul. – Sept. 2004
iii. Visiting Associate to Institute of Theoretical Physics Beijing, - China.	Third World Academy of science (ICTP- Italy)	Sept. – Nov. 2002
iv. Research grant for research on children's science literacy	AFCLIST Durban, South Africa	2002 - 2003
v. Research grant for evaluation of the Science Resource Centres in Ghana	Univ. of Education Winneba, Ghana.	2001 - 2003
vi. Research Grant for evaluation of continuous assessment	Univ. of Education and World Bank.	1997 - 1999
vii. Scholarship Award for studies in Manchester, U.K. for M. Sc.(Theor. Physics)	Ghana Government	Sept.1992 - April, 1995

## **5. Employment**

<b>Institution</b>	<b>Position Held</b>	<b>Dates</b>
i. University of Education	Snr. Lecturer	Currently
ii. Kwame Nkrumah Univ. of Science and Technology, Kumasi	Sabbatical Leave	Oct. 2001 - Sept. 2002
iii. University of Education, Winneba	Lecturer	1995 – to date
iv. Advanced Teacher Training College Winneba	Physics Tutor	Feb. 1983 - Oct. 1992
v. Alamuwa Grammar School, Ado-Odo, Ogun State, Nigeria.	Physics Tutor	Oct. 1979 - Sept. 1982

vi. St. Peter's Secondary School, Nkwatia-Kwahu.	National Service Physics Tutor	Sept.1978 - Sept. 1979
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## 6. Ghana Education Services Grades Ranks

## Dates

Promoted to Principal Superintendent	Sept. 1991
Promoted to Senior Superintendent	Sept. 1984
Appointed Superintendent	Sept. 1978

## 7. Published articles in refereed journals

- i. **Amedeker, M. K & Antwi, V.** (2007). Assessment practices used by physics teachers in senior secondary schools: Are our students informed? *International Journal of Education Studies*, **3** (1), 126 - 134
- ii. **Nandi, K. K., N. G. Migranov, Evans, J. C. and Amedeker, M. K.** (2006). Planetary and light motions from Newtonian theory: An amusing exercise. *Eur. J. Phys.*, **27** (2), 429 – 435
- iii. **Amedeker, M.K.** (2005). Reforming Ghanaian teacher education towards preparing an effective pre-service teacher. *Journal of Education for Teaching*, **31** (2), 99 – 110
- iv. **Amedeker. M. K., Li, Q.F.** (2005). On the coupling of  $\Phi$  Meson to Nucleons and Backward  $\Phi$  Production. *Commun.Theor.Phys. (Beijing China)*, **43** (3), 493 – 496.
- v. **Amedeker, M. K.** (2004), The Dual mode of light. *Everyday Science for Schools*, **3**(1), 15 – 17
- vi. **Amedeker, M. K., Li, Q. F. and Zou, B. S.** (2003). Vector meson couplings to nucleons and backward  $\rho$  and  $\omega$  production. *Commun.Theor.Phys. (Beijing China)*, **39** (6), 667 – 670.
- vii. **Amedeker, M. K. and Tamakloe, W. L.** (2003). Teaching and Assessing Affective skills in Science in Ghanaian Basic Schools. *Journal of the Ghana Science Association*, **5** (1), 163 – 173.
- viii. **Amedeker, M. K.** (2002). Science teacher trainees in a school attachment programme. *Journal of Education and Teaching (U.K)*, **28** (1), 61-71.
- ix. **Aboagye, J. K., Atta-Boison, G. K. and Amedeker, M. K.** (2001). Is continuous assessment the panacea for pupil appraisal in junior secondary schools? *EDUCALERT – A periodic release of University College of Education of Winneba*, **2**(1), 1 – 3
- x. **Amedeker, M. K.** (2000). Alternative assessment as an ingredient of continuous assessment in junior secondary schools. *Journal of the Ghana Science Association*, **2** (1), 1-11.
- xi. **Amedeker, M. K.** (2000). Quarks: The fundamental particles. *Everyday Science for Schools*, **2** (1), 14 – 17.
- xii. **Benjamin, M. A. and Amedeker, M. K.** (2000). The effect of the absence of selected mineral elements on the growth of maize seedling. *NATT RESEARCH SERIES –A journal publication of the Nigerian Association of Teachers of Technology*, **4** (1 & 2), 1 – 7.

- xiii. **Amedeker, M. K. and Benjamin, M. A.** (1999). Ethnoscience: Africa's contribution to World Science. *Mate Masie – Journal of the University College of Education, Winneba*, **1**, 143 – 155.
- xiv. **Amedeker, M. K.** (1999). The changing attitudes towards girls' education in science in Ghana. *Ghana Journal of Education and Teaching (GHAJET)*, **1** (1), 141 – 151.
- xv. **Amedeker, M. K.** (1998). The place of native language in science teaching and learning in the junior secondary schools in Ghana. *Journal of the Ghana Science Association*, **1** (1), 7 – 11.
- xvi. **Amedeker, M. K.** (1998). The search for fundamental particles. *Everyday Science for Schools*, **1** (2), 21 – 24.
- xvii. **Benjamin, M. A. and Amedeker, M. K.** (1997). Teaching a model lesson to the child with hearing impairment in a regular junior secondary school classroom. *Ghanaian Journal of Special Education*, **1** (2), 34 – 38.

## **8. PUBLICATIONS IN UNIVERSITY BULLETIN**

- i. **Amedeker, M. K.** (2000). Popularising physics in our schools. *THE WEB (Winneba Educational Bulletin)*, **1** (8), 16 – 18.
- ii. **Amedeker, M. K.** (1999). Teaching and learning science in a superstitious society. *THE WEB (Winneba Educational Bulletin)*, **1** (6), 23 – 28.
- iii. **Amedeker, M. K.** (1999). Ozone layer depletion: A problem for an entire planet. *THE WEB (Winneba Educational Bulletin)*, **1** (5), 12 – 14.
- iv. **Amedeker, M. K.** (1999). Lasers: A great leap in scientific and technological development. *THE WEB (Winneba Educational Bulletin)*, **1** (4), 21 – 24.

## **9. Publication in Book of Reading**

**Amedeker, M. K.** (1999). Coping with the problem of low vision in a regular science class: A case study at the University College of Education, Winneba. *Pre-plan for Special Education service in Ghana in the 21<sup>ST</sup> Century*, 111 - 114.

## **10. Published Books**

- i. **Amedeker, M. K. et al.** (2002). Manual for teaching Psychosocial Life Skills. Ministry of Education (CRDD): Accra pp. 169
- ii. **Amedeker, M. K. et al.** (1998). Measurement and Analysis. Institute for Educational Development and Extension (Distance Education), Univ. College of Education, Winneba. pp. 356

## **11. Dissertation/Thesis**

- i. The status and quality of continuous assessment in junior secondary science in Ghana. A Ph. D. thesis submitted to Edith Cowan University, Perth. Western Australia, (December, 2007).
- ii. OZI rule violation in backward vector meson production. M.Sc. Dissertation submitted to the University of Manchester, Manchester, U. K. (April, 1995)

## **12. Papers/posters presented at conferences, seminars and workshops**

- i. Poster presentation: The status and quality of continuous assessment in junior secondary science in Ghana – Conference of the Western Australian Science Educators Association, Edith Cowan University, Perth, - November 30, 2006.
- ii. Prospects for implementing assessment for learning in Ghanaian junior secondary science – Faculty of Science Education Seminar, University of Education, Winneba. Ghana. - 24<sup>th</sup> February, 2006
- iii. Backward photoproduction of  $\phi$  mesons in Kp interactions – Institute of Theoretical Physics Seminar, Beijing - September, 2004
- iv. On the coupling of  $\phi$  meson to nucleons and backward  $\phi$  production – Mentouri University, Constantine, Algeria 3 – 08 April, 2004
- v. The Ghanaian primary School Pupils' Concept of Energy. West African Examinations Council Monthly Seminars, Accra. - 30<sup>th</sup> May, 2003.
- vi. Deriving the differential cross-section formula using simple tree diagram, Institute of Theoretical Physics, Beijing, China. - Oct. 2002.
- vii. Teaching and assessing affective skills in science in Ghanaian Basic Schools. West African Examinations Council Monthly Seminars, Accra - 23<sup>rd</sup> February, 2001.
- viii. The Use of Computer-Aided Strategies for teaching physics in the Pre-tertiary institutions- presented at the 44<sup>th</sup> Annual National Conference of the Ghana Association of Science Teachers at Tamale - September, 2000.
- ix. Towards a theoretical framework for improving assessment in science in the junior secondary schools in Ghana. West African Examinations Council Monthly Seminars, Accra - 1<sup>st</sup> October, 1999.
- x. Promoting Quality Science Teaching and Learning through alternative assessment: The case of the continuous assessment in junior secondary schools – presented at the 21<sup>st</sup> Biennial Conference of the Ghana Science Association – University of Ghana, Legon 8<sup>th</sup> – 13<sup>th</sup> August, 1999.
- xi. Coping with the problem of low vision in a regular science class: A case study at University College of Education, Winneba – presented at 1<sup>st</sup> National Conference on Special Education at Winneba – August 1998.
- xii. The Place of Native Language in science teaching and learning in the Junior Secondary Schools in Ghana – presented at the 20<sup>th</sup> Biennial Conference of the Ghana Science Association at the Kwame Nkrumah University of Science and Technology, Kumasi - August, 1997.

- xiii. The role of physics in a developing industrial world presented at the 36<sup>th</sup> Annual National Conference of the Ghana Association of Science Teachers conference at Ho - September, 1992.

### **13. Citation**

In Honour of active participation in the Conferences of Special Education, contributions towards publications in the Journal of Special Education and introducing science teaching to people with disabilities From Association of Special Education Students, University College of Education, - Winneba (1999).

### **14. Membership of Professional Associations**

- i. Institute of Physics with Chartered Physics status (U.K) - since 1997
- ii. Ghana Science Association (GSA)- since 1996
- iii. Ghana Association of Science Teachers (GAST) - since 1983

### **15. Courses, Seminars, Workshops and Conferences Attended**

- i. Western Australian Science Educator Association Conference, Edith Cowan University, Perth, Western Australia - presented Poster November 30, 2006.
- ii. Conference on Meson and Nucleon Physics, Institute of High Energy Physics - Beijing, China, 31<sup>st</sup> July to 4<sup>th</sup> August, 2004
- iii. Conference on High Energy Physics        Mentouri University, Constantine, Algeria, presented paper, 4-8<sup>th</sup> April, 2004
- iv. Conference on Harnessing Science Research and Technology for National Development –Accra International Conference Centre    15-19 March, 2004
- v. African Summer Theory Institute – Cape Town, South Africa    (Summer School), Jan. 9 – 31, 2004
- vi. West African Examinations Council Monthly Seminar, Accra – presented paper - May, 2003
- vii. International Conference on Mesons, Beijing-China - presented paper Oct., 2002
- viii. West African Examinations Council Monthly Seminar, Accra – presented paper Feb. 2001
- ix. West African Examinations Council Monthly Seminar, Accra – presented paper Oct. 1999
- x. Training workshop for Designing Modules for training JSS teachers in teaching Life Skills in science- sponsored by Ghana Education Service, Akropong-Akwapim, Ghana - Oct/Nov. 1999
- xi. Ghana Science Association 21<sup>st</sup> Biennial Conference at Legon, Accra – presented paper, Aug. 1999
- xii. Regional College on Optics education for Tertiary Level Teachers and Researchers at University of Cape Coast, Cape Coast, Ghana sponsored by Abdus Salaam Institute of Theoretical Physics, Trieste, April, 1999

- xiii. First Joint National Conference on special Education at Winneba- presented paper Nov. 1998
- xiv. Workshop for Instructional Design and Editing of Distance Education materials- sponsored by Simon Fraser University, U.S.A., at Winneba, Nov. 1998
- xv. STAG Project Development Workshop sponsored by AFCLIST, Winneba Oct. 1998
- xvi. Seminar/Workshop for Universities Research Funded Researchers at - STEPRI, Accra, Feb. 1998
- xvii. Training Workshop for Hall Counsellors, Winneba, Nov. 1997
- xviii. Ghana Science Association 20<sup>th</sup> Biennial Conference and Workshop- presented paper, Kwame Nkrumah University of Science and Technology, Kumasi - August, 1997
- xix. New Year School – Organised by Institute of Adult Education (Legon) - Jan. 1997
- xx. Workshop for Distance Education Materials Writing, Winneba July, 1995
- xxi. Test Item Writers Workshop- West African Examinations Council sponsored, Winneba August, 1991
- xxii. Second West African Physics Teachers workshop at Ibadan, Nigeria- Ghana Association of Science Teachers sponsored, Sept., 1991
- xxiii. Trainer of Trainers Workshop –Primary Science Ghana Education Service sponsored, Ajumako, July, 1991
- xxiv. Trainer of Trainers Workshop – J.S.S. Science Teaching Ghana Education Service sponsored, Ajumako - Jan. 1990
- xxv. Yearly Science workshops organized by Ghana Association of Science Teachers – from 1984

## **16. Administrative Experience**

- i. Ag. Head, Department of Science Education, University of Education, Winneba, Ghana, 2002/2003 - 2003/2004
- ii. Departmental Examination Officer, 1996 – 2001
- iii. Departmental Time Table Officer, 1996 – 2001
- iv. Hall Counsellor, AMU Hall, University of Education, 1996-1998
- v. Departmental Staff Secretary, Advanced Teacher Training College, Winneba. 1984 – 1987
- vi. Chairman, Transport Committee, Advanced Teacher Training College, Winneba. 1989 – 1992
- vii. Hall Warden, Nana Ghartey Hall, Advanced Teacher Training College, Winneba. 1989 -1992
- viii. Assistant National Secretary, Ghana Association of Science Teachers, 1986- 1992
- ix. Regional Chairman, Central Region, Ghana Association of Science Teachers, 1984 – 1986
- x. Hall Warden, Kotoka Hall, Advanced Teacher Training College, Winneba, 1984 - 1986
- xi. Sectional Head (Physics), Department of Science Advanced Teacher Training College, Winneba. 1983 – 1987

## **17. Experience in Editing**

- i. Edited articles for World Conference on Science & Technology Education, ICASE 2007, to be held in Perth, Australia, 8 – 12 July, 2007
- ii. Writer and Editor, Distance Education materials, 1995 – 2001
- iii. Science Editor, Nyansapow Journal for Pre-University science students, 1996 - 1997

## **18 University Committees Served On**

- i. Member of University of Education Academic Board, 2002/2003 & 2003/2004 academic years
- ii. Member , University Estate Management Committee - Oct. 2003 - Feb. 2005
- iii. Member, University Committee to investigate Admissions Malpractice - Oct., 2003
- iv. Chairman, University Committee to investigate Examinations Malpractice Sept.2003.
- v. Chairman, Senior Members and Senior Staff Association (SEMSA), University of Education, Winneba, 1999 – 2001
- vi. Board Member, UCEW WINDY BAY F.M. RADIO, 1999- 2001
- vii. Member, Committee for restructuring of academic programmes - Sept. 2000
- viii. Member, Education Sector analysis Committee – University College of Education, Winneba, Ghana - Sept. 1998
- ix. Member, Sub-Committee on Free Compulsory Universal Basic Education - Academic Board Appointment - Feb. 1996
- x. Board Member - Faculty of Science Education, University College of Education, Winneba. Ghana - 1995 – 1996

## **19 National Committees Served On**

- i. University of Education's Representative - Working Committee of the Ghana Academy of Arts and Sciences, 1998 – 2001
- ii. Member, National Working Panel to review the WASSCE Core Science Syllabus –appointment by West African Examinations Council - June, 2001
- iii. Member, Working Committee to compile the Integrated Science Syllabus for Senior Secondary Schools – West African Examinations Council sponsored - May, 1998
- iv. Member, Working Committee to Review the Junior Secondary School Science Syllabus – Ghana Education Service sponsored, July/Aug. 1997

## **20 Interests and Hobbies**

- Gardening/Observing nature
- Swimming



## **21 Research Interests**

- i. Integration of assessment and instruction for supporting students' learning of science
- ii. Assessment and Evaluation
- iii. Teaching science in deprived schools: Basic and Secondary schools
- iv. Teacher Education/Physics Education
- v. Backward meson production
- vi. Photo-production of mesons and coupling of mesons to nucleons

## **Courses Taught At the University of Education**

### **PHY 111 – Mechanics and Properties of Matter – 2 Credits**

Scalar and Vector Quantities; Vector Algebra; Rectilinear and Circular Motion; Simple Harmonic Motion; Collisions; Gravitation; Rigid Body Motion and Statics of Rigid Bodies; Elasticity of solids; Surface Tension and Viscosity

### **PHY 121 – Heat and Thermal Physics – 2 Credits**

Thermometry; Heat transfer; Calorimetry; Specific heat Capacity; Latent heat; Kinetic Theory and Ideal gas law; Real gases and liquefaction of gases; First and Second Laws of Thermodynamics; Carnot Cycle and Heat Engines; Vapours and Relative Humidity.

### **PHY 231 – Waves, Sound and Optics – 3 Credits**

Vibrations in pipes and rods; Wave Equation; Reflection in mirrors; refraction in prisma and lenses; Dispersion, Interference and Diffraction; Polarisation; Wave-Particle Duality; Newton's Corpuscular theory; Huygen's wave theory.

### **PHY 241 – Electricity and Magnetism – 2 Credits**

Electrostatic forces; electric field intensity ; electric potential; capacitors, dielectrics; d.c. circuits, Kirchoff' laws; d.c. measuring instruments; Heating effect; magnetic field and flux; force on moving charges and current – carrying conductors; law of induction; Galvanometers, motors and a.c. generators; self-inductance and natural inductance; Trasformers; a.c. circuits; r.m.s. and peak values; Impedance; Power factor; phasor diagrams; resonance; transmission of alternating currents.

### **PHY 351 – Atomic and Nuclear Physics – 3 Credits**

Atomic Models. The hydrogen atom; atomic spectra; X-rays; electronic structure of the atom; Zeeman effect; Nuclear models; nuclear processes and natural radioactivity; particle accelerators; fission and fusion; fundamental particles.

### **PHY 361 – Electronics – 3 credits**

Intrinsic and extrinsic semiconductors; p-n junction diodes; rectification of a.c. currents and voltages; transistors, amplifiers, oscillators; multivibrators, Integrated Circuits; Operational amplifiers; Digital Logic circuits and applications.

### **ISE 431 – Communicating in the Science Lesson – 2 Credits**

Effects of bilingualism on science learning in schools; the language of science and optimum use of science text-books; Teacher-pupil interaction; the social structure of the classroom; social skills of the teacher; the impact of authority; discipline, freedom, responsibility, conformity and self-confidence on children's science learning.

### **ISC 441 – Communication – 3 Credits**

Sources of sound; propagation of sound. Musical instruments- drums, pipe organs, xylophone etc. Modern communication: electromagnetic spectrum, radio communication, telegraphy, telex, fax, earth satellites etc. Broadcasting: A. M. and F.M. transmission. Acoustics, T.V. transmission, Video and closed circuit T.V. transmission.

### **PHY 442- Further Topics in Electronics – 3 Credits**

Energy Bands; effective mass concept; hole concept; conductivity and mobility; Fermi levels; Amplifiers- classes of operation. Construction of practical stabilized amplifiers. Operational amplifiers; Oscillators; Bistable multivibrators; Digital logic circuits

### **PHY 443- Quantum Physics – 3 Credits**

Particle nature of light; Bohr theory; de Broglie's theory. Wave nature of particles; Schrodinger's wave equation. Normalisation; Schrodinger's time-independent wave equation; Correspondence principle and Uncertainty principle. Potentials; step and barrier potentials. Tunnelling ; Operator formalism; One dimensional systems; The hydrogen atom ; Independent electron states in atoms. Electron spin.

## **COURSES STUDIED FOR M.Sc. (THEORETICAL PHYSICS)**

### **PG 03 Advanced Quantum Mechanics (10 Credits)**

Path Integral formulation of Quantum Mechanics. W-K-B approximation. Absorption and emission of radiation. Dirac equation(including covariance, parity time reversal; charge conjugation; plane wave solutions, connection with non-relativistic wave equation. Hydrogen atom. Density matrices. Particle number representation

### **PG 04 Quantum Field Theory I (10 Credits)**

Canonical quantization of discrete systems. Lagrangians and Hamiltonians. Transition to continuum dynamics. Quantization of Klein-Gordon Field. Invariance and conservation laws. Pauli-Jordan function. Particle interpretation of quantum field theory. Fock space. Interacting fields. Interaction pictures. In-out formation. S-operator. Perturbation theory. Time-ordered products and Wick's theorem. Feynman diagrams. Scattering amplitudes. Quantisation of Dirac field. Interaction with external electromagnetic field. Gauge Invariance. Feynman rules.

### **PG 05 Quantum Field Theory II (10 Credits)**

Quantum electrodynamics; quantization of electromagnetic field; Feynman rules; Green's functions and S-matrix elements; Generating functionals and path integrals; scalar fields; Dirac field; electromagnetic field; non-Abelian. Renormalisation of  $\lambda\phi^4$  theory ; mass and coupling content; Renormalisation (1 loop); dimensional regularization; renormality; renormalization group

**PG 06 Quarks and Partons (10 Credits)**

The quark model of hadrons; flavor, colour, isospin; elementary group theory for SU(2) and SU(3). Partons' relativistic wave equations; perturbation theory for electrodynamics; scattering amplitudes and cross-sections; deep inelastic scattering; The parton model.

**PG 07 Introduction to Gauge Theories (10 Credits)**

Gauge invariance in quantum electrodynamics. Non-Abelian gauge theories. Spontaneous symmetry breaking and the standard model. Quantum chromodynamics. Running coupling constants and asymptotic freedom.

**PG 09 Introduction to General Relativity (10 Credits)**

Tensors; review of special relativity; general relativity. Black holes and cosmology. Test of Einstein' theory of relativity; gravitational radiation and stellar structure.

**PG 12 Mathematical Methods (10 Credits)**

Complete sets of functions and principle of superposition; applications to partial differential equations; eigenfunctions and Sturm-Liouville problems. Inhomogeneous equations; Green's functions; Fourier transform method for infinite spaces; applications to PDEs, including wave equations; electromagnetism and Schrodinger's equation. Calculus of variations; constraints; connection to eigenvalue problems; variational methods including Rayleigh-Ritz and applications, in particular to Quantum Mechanics. Integral equations. Fredholm equations of the first and second kinds. Scattering of waves.

**PG 40 High Energy Kinematics (5 Credits)**

Lorentz transformations. Four-vectors and invariants. Detailed transformation of a four-momentum and the polar angle. Rapidity; natural units. Two-body reaction kinematics; cross-section; phase space; evaluation of two-body and three-body phase space. Dalitz and Mandelstam plots. Partial wave expansions. Breit-Wigner formula.

**PG 44 Particle Physics (10 Credits)**

Elementary particles. The Gauge Principle. Resonances, decays, collisions. Additive quantum numbers. Strange particles. Charm. Isospin. Quark multiplets. Multiplicative quantum numbers. Parity violation. The  $K^0 - \bar{K}^0$  system. The 3<sup>rd</sup> generation. Dynamical quarks. The Standard Model. The Big Bang. Towards a theory of everything. Accelerator. Detectors.

**PG 53 Laser Physics (10 Credits)**

Semi-classical treatment of absorption and refraction. Natural pressure broadened and Doppler spectral profiles. Planck Distribution. Einstein's A and B coefficients. Lasers- two-level and multi-level systems; threshold condition; modes and their selection. Doped insulator lasers; gas-discharge lasers; dye lasers, semiconductor lasers. Properties and uses of lasers. Light- holography. Non-linear processes; frequency doubling and mixing.